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SUMMARY OF PRECIPITATION MONITORING PROGRAM NORTH CASCADES NATIONAL PARK COMPLEX 1980-1985

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Chief
Water Resources Division
National Park Service
301 South Howes Street
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SUMMARY OF PRECIPITATION MONITORING PROGRAM
NORTH CASCADES NATIONAL PARK COMPLEX
1980-1985

Sarah Spaulding
Water Resources Division
National Park Service
301 S. Howes Street
Fort Collins, CO 80521
May 1987

Robert Wasem
Management Biologist
North Cascades National Park
Sedro-Woolley, WA 98284

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ABSTRACT

An acid precipitation monitoring program was initiated in the North Cascades National Park Service Complex (consisting of North Cascades National Park, Ross Lake National Recreational Area (NRA), and Lake Chelan NRA) in February of 1980. The project was designed to operate for many years in order to establish baseline data and monitor long term trends at a number of sites in the national park complex. Because of increasing concern over acid rain in the Northwest, the study is intended to give an indication of the variability of the pH of rainfall and the effects of industrial emissions in northern Washington on the North Cascades National Park Service Complex (NOCA Complex). Conductivity, pH, and volume of precipitation were measured at six sites. The purpose of this report is to present a summary of the data and to determine if the NOCA Complex is being impacted by acid rain. In some years annual mean pH values were below the 4.5 limit of the natural variability of rainfall. The precipitation collectors were located in close proximity to vegetation, work areas, and dwellings. Consequently, it is not possible to determine if the acidic precipitation can be attributed to regional sources. The results are compared with the National Acidic Deposition Program/National Trends Network (NADP/NTN) site located near the NOCA Complex (Marblemount) and with the NADP/NTN site at Olympic National Park. The pH values analyzed from the NOCA program were found to be lower than those

measured at Marblemount and considerably lower than those at Olympic National Park.

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INTRODUCTION

Authority for maintaining the air quality of the NOCA Complex is found in the National Park Act of 1916, National Park Service resource management guidelines and policies, and the Clean Air Act of 1970 with 1977 amendments (Sec. 160-169). The latter provides for the prevention of significant deterioration in Class I Areas (e.g. national parks and wilderness areas) and allows for pollution that would accompany moderate, well-planned growth in Class II Areas (e.g. National Recreation Areas and National Forests not classified as wilderness). Man-caused acid precipitation has been well documented through numerous and exhaustive studies in Europe and the eastern United States. In comparison, the number of such studies conducted in the northwestern United States have been few. There is little information on the effects of air pollution on the remote mountain areas of the Pacific Northwest. The North Cascades National Park Service Complex (NOCA Complex) receives air masses that have blown across several large urban-industrial areas of Puget Sound. As a result, there is the potential for deterioration of air quality. The purpose of this report is to determine if the NOCA Complex has received acid precipitation over the time period from 1980 to 1985.

Sulfur and nitrogen oxides from fossil fuel combustion have been shown to decrease the pH of precipitation (Haines,1981). In the atmosphere, sulfur dioxide (SO_2) and

nitrogen compounds (NO_x) can be transformed into sulfuric and nitric acids. When it rains or snows, the acids are washed out of the atmosphere. In November of 1972, Larson et al. (1974) measured acid precipitation near a large industrial SO_2 source in the Puget Sound region of Washington. Values of pH were found as low as 3.7. A second study in the Cascade Mountains found that sulfate concentrations were higher in snow cores downwind of major metropolitan and industrial areas than in snow cores from other areas of the Cascades (Laird et al.,1986). A third study in the Cascades determined that the volume-weighted mean pH ranged from 4.68 to 4.84 (Logan et al.,1982). These values, measured over a period of seven months in 1981, do not fall below the value (4.5) that has been suggested as the lower limit of natural variability (Charlson and Rodhe,1982). These studies indicate that some areas of the Cascade Mountains can be significantly affected by industrial regions while others are not. Thus, available documentation is inconclusive as to the geographic boundaries and seriousness of industrially-related acid deposition in the northwest.

The geochemistry, geomorphology, and hydrology of a watershed determine the capacity of water and soil to neutralize acids. The pH of a lake is determined not only by the acidity of the precipitation but also by the processes that take place in the lake and surrounding terrestrial area. A lake that is susceptible to acidification is one in which the water and soils have a low buffering capacity, indicated by a lake alkalinity of

less than 200 microequivalents per liter (ueq/l). Researchers in Washington have found such lakes in the Cascades, with alkalinities ranging from 4 to 190 ueq/l (Logan et al.,1982). In addition, 7 out of 19 lakes in the Alpine Lakes Wilderness were found to have pH values ranging from 4.5 to 5.5 (Welch and Chamberlain, 1981). It is not clear whether these lakes are naturally acidic or have degraded in recent time. Because of the sensitive nature of the region and the inconclusive and small number of studies, there is a need to monitor the quality of precipitation in the North Cascades.

Winds prevail from the west, passing over the populated Puget Sound region before reaching the NOCA Complex. Thus, NOCA Complex may be influenced by both point sources (large, single sources) and area sources (combination of small point sources such as cities) of acid precursors originating in the Puget Sound region. The two major point sources of industrially-released sulfur in Washington are Puget Power in Centralia and ASARCO, a copper smelter in Tacoma. Puget Power releases 56,000 tons per year and ASARCO released 70,000 tons per year until it closed in June of 1985 (Maykut, 1986). During a single rain event there were measured effects on rain chemistry up to 40 km downwind from the smelter (Larson et al., 1974). Values of pH were found to be as low as 3.71. The Seattle metropolitan area is also a large source of both sulfates and nitrates. In addition, in close proximity to the complex, Skagit county and Whatcom county produce 13,900 and 16,000 tons per year of sulfate, respectively.

In addition to industrial sources of sulfates, there are natural sulfate point sources. Mount Saint Helens is a natural source of sulfate, located 260 km south of the North Cascades Complex. In 1983, Mt. St. Helens emitted approximately 45,000 tons of SO_2. However, it is unlikely that Mount Saint Helens emissions affected NOCA since winds generally do not reach NOCA from Mount Saint Helens. The eruptions did not affect the precipitation pH of a site at Stampede Pass, approximately 140 km south of the NOCA Complex (Logan et al., 1982).

The most significant natural source of sulfur is from sea salts. It has been found that sea salts may be an influence up to 100 km inland (Unified Deposition Data Base, 1980). Sea salt might be expected to increase, or have no effect, on pH and conductivity. For the purposes of this report, sea salt influence on pH will not be considered.

STUDY AREA

NOCA Complex (Figure 1) is characterized by rugged mountains with timbered rocky slopes. The gneiss and schist bedrock has been glaciated to produce jagged peaks, U-shaped valleys, and sheer cliffs. The northern Cascades were probably lifted higher and are more eroded than other portions of the Cascade Range. There are about 318 glaciers in the North Cascades Complex. Although much of the Cascade Range was influenced by volcanic activity, there are no volcanos within the National Park Complex.

Glacier Peak to the southwest and Mt. Baker to the west had major eruptions 12,000 and 15,000 years ago, respectively.

A geologic sensitivity to acid rain in the park complex was determined based on Norton et. al. (1982). The NOCA biological staff determined that twenty-two percent of the bedrock has low, to no acid neutralizing capacity. In these areas widespread effects on aquatic ecosystems would be expected in the event of acidic precipitation. Sixty-three percent of the complex has a medium to low acid neutralizing capacity. Here, effects from acidic precipitation would be restricted to first and second order streams and small lakes. The remaining fifteen percent of the complex has bedrock of high to medium acid neutralizing capacity. In areas of the third bedrock type, effects from acidic precipitation are unlikely.

Within the Complex there are approximately 250 lakes and ponds and three large reservoirs. The northern edge of Lake Chelan, a lake modified for hydroelectric power, is also included in the Complex. Some lakes bordering on active glaciers appear and disappear depending on glacial retreat and advance. The high elevation lakes are naturally barren of fish life, however, some support introduced populations of trout. The primary species in these lakes are cutthroat and rainbow trout, but a few lakes also contain brook, golden, and cutthroat/rainbow trout hybrids. Lower elevation reservoirs and streams support a greater variety and abundance of fish life. In addition to the above mentioned trout species (except golden), five species of salmon, mountain

whitefish, two species of sucker, peamouth chub, northern squawfish, bull trout, Dolly Varden, longnose dace, burbot, and several species of sculpin inhabit lower elevation waters.

The elevations of the NOCA Complex range from 110 meters near Marblemount to 2806 meters on Mt. Goode. On the western slope of the Cascades the volume of precipitation increases with elevation. By the time storms pass to the east of the Cascade crest they have lost most of their moisture. Mt. Baker on the west receives 2790 mm average annual precipitation while Stehekin on the east receives 860 mm.

The NOCA Complex is managed primarily as a wilderness area. Recreational use in the backcountry includes hiking, camping, and mountaineering. Developed campgrounds, boating, fishing, and sightseeing activities are largely confined to the highway 20 corridor, Hozomeen, the north end of Lake Chelan, and the lower Stehekin River valley.

METHODS

Beginning in February of 1980, precipitation samples were collected after every storm at the Sedro-Woolley site. Additional collection sites were established at Marblemount, Stehekin, Hozomeen, Newhalem, and Ross Dam (Table 1, Figure 1). Precipitation, including rain and snow, was sampled from standard plastic rain collectors mounted on two meter posts. The collectors were inadvertently located such that they may have

been influenced by nearby structures, vegetation, and roads (Table 2). The collectors consist of a 101 mm diameter funnel leading into a calibrated inner tube having a depth of 257 mm and diameter of 31 mm. The inner tube holds 208 mls of liquid. For volumes greater than 208 mls, the sample flows into an outer reservoir. At the time of collection, samples were transferred to clean plastic bottles. The inner tubes, outer tubes, and funnels of the collectors were cleaned by rinsing several times with deionized water. The collectors were then wiped dry or allowed to air dry before being replaced on the collector post. All precipitation samples, except for Hozomeen samples, were processed at the Sedro-Woolley NPS laboratory. Hozomeen samples were analyzed by the Skagit District rangers at the site. Most samples were analyzed the day of collection and all samples were analyzed within four days of collection. Samples were refrigerated until they were processed.

Sedro-Woolley samples were collected after every storm. Stehekin samples were collected twice a week. Marblemount, Newhalem, and Ross Dam samples were collected at least once a week (sometimes twice a week). Samples were collected at Hozomeen after every storm between early May and the end of October (Table 1). Precipitation was analyzed for pH and specific conductance. During the period of study a number of different meters and probes were used for pH determination. Not all of these met the EPA precision and accuracy standards for low ionic strength solutions. Before each sample was tested, the pH

meter was standardized with pH 7 and 4 buffers at or near the temperature of the sample (25 C). The electrode was rinsed several times during the standardization process with deionized water and blotted dry. The electrode was allowed to soak for 4-5 minutes in a sample aliquot, then placed in a second sample aliquot. The sample was swirled for approximately 15 seconds and then the meter was allowed to reach a stable reading (4-12 minutes). Samples that were contaminated with a significant amount of foreign matter (insects,conifer needles,etc.) were discarded.

Volume weighted mean annual and monthly pH and conductivity values were calculated. The volume weighted mean was calculated by summing the concentration (of hydrogen ion) and the sample volume on each date divided by the total annual (or monthly) volume.

In February of 1984 a NADP/NTN site was established at Marblemount. NADP/NTN samples are collected and analyzed according to NADP protocol. Chemical differences between weekly and event samples may occur and could be attributed to chemical degradation that occurs in the time until processing (Sisterson et al., 1985). Weekly samples are expected to have higher pH values than event samples. For purposes of a general comparison, the Marblemount NADP/NTN data are presented, as well as the Olympic National Park NADP/NTN data.

DISCUSSION

The data presented below are from rainfall events. Snowfall events and mixed events proved to be too infrequent to compare with rainfall. There was no significant correlation between pH and volume. Likewise, there were no significant correlations between the sites' elevation and pH.

Plots of annual mean pH at Stehekin, Marblemount, and Sedro-Woolley show similar trends of decreasing in 1982, and increasing in 1983 and 1984 (Figure 2). Stehekin and Marblemount have similar patterns of increase. This is in contrast to Sedro-Woolley which indicates a pattern of annual variation more comparable to the NADP Olympic site, even though there is a large difference in individual values. The corresponding annual mean conductivity values indicate an inverse relationship with pH (Figure 3). In years that pH increases, there is a decrease in conductivity. Conductivity depends, among other things, on the presence of ions and their total concentrations.

The pH of natural rainwater is controlled not only by the dissociation of dissolved CO_2, but also by naturally occurring acids in the atmosphere. Based on the variability of naturally occurring sulfur alone, pH values may be expected to range from 4.5 to 5.6 (Charlson et al., 1982). When annual mean pH values were considered, there were a number of years in which the values fell below this limit of natural variability (1981:Sedro-Woolley, 1982:Sedro-Woolley, Stehekin, Marblemount, 1985:Newhalem). The

lowest annual mean pH of 4.30 was found at Stehekin in 1982. When monthly mean pH values were considered, Sedro-Woolley had pH values below 4.5 for most months in 1980, 1981, 1982, and 1983.

In Figures 4 and 5, pH is shown as monthly means for Sedro-Woolley. There is a general trend of decreasing pH from January to August, followed by an increase in the latter months of the year. This pattern appears to be consistent for the years 1980-1983. In 1984 and 1985, the summer pH depression is not as clear; there were fewer rainfall events. Graphs of monthly means from Stehekin and Marblemount are shown in Figure 6.

The Marblemount NADP/NTN site has consistently higher pH values than the Marblemount NOCA site (Figure 5 and 6b). The mean annual pH values were 4.96 and 4.92 for 1984 and 1985. Instead of monthly values, NADP/NTN data are listed in this report as seasonal values. As shown in Figure 6b, they also show a pH depression in summer.

The Olympic National Park NADP/NTN site has been in operation since 1980. It is located where it receives ocean air masses with negligible pollution. The mean annual pH ranges from 5.33 to 5.47, for the years 1980-1985 (Figure 7). These values are substantially higher than any of the park complex sites or the Marblemount NADP/NTN site.

At this time, limited work has been done to determine the chemical constituents of the park complex samples (Table 1). The data should be used with caution because of the small number of samples and the detection limits for sulfate, which were high

(1.0 mg/l). Based on three samples from Sedro-Woolley, sulfate values range from less than 1.0 mg/l to 1.5 mg/l. The mean SO_4 concentration for the NADP/NTN Marblemount site was 0.87 mg/l in 1984 (NADP, 1984). In the eastern United States, where substantial sulfate concentrations in precipitation occur, the concentrations range from about 1.5 to 3.0 mg/l.

CONCLUSIONS

There are many recorded instances of acidic precipitation in North Cascades National Park Complex. When all sites were considered, monthly mean pH ranged from 3.82 (June 1980, Sedro-Woolley) to 5.22 (March 1984, Stehekin)(Appendix). In some years annual mean pH values were below the 4.5 limit of the natural variability of rainfall. In general, pH has increased over the time interval from 1980 to 1985. The NOCA collectors were located in areas such that incoming precipitation may have received local influences, making it difficult to determine if the low pH values can be attributed to regional acid precipitation.

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TABLE 1

Information on the six Precipitation Collecting Stations at North Cascades National Park Complex

SITE	Sedro Woolley	Marblemount Ranger Station	Newhalem Campground	Ross Dam Trailhead	Stehekin	Hozomeen
Begin Date	2/2/80	11/17/80	2/21/84	8/30/85	4/81	10/1/82
UTM Coordinates	N 5375000 E 556000	N 5377500 E 614500	N 5392000 E 62800	N 5398900 E 642700	N 5357400 E 669300	N5423100 E 641500
Elevation	15 m	100	200	650	350	501
Dist. to Saltwater	18 km	72	87	102	122	108
Collection	event	1 or 2/week	1 or 2/week	1 or 2/week	2/week	event May-Oct 1 or 2/week Nov-Apr

TABLE 2

		type	height(m)	distance(m)
Marblemount				
	structures:	weather shelter	2.5	4
		bunk house	6	13.5
	trees:	shrub	3	2.5
		shrub	3	4
		spruce	4.5	25
	roads:	service	-	15
		public	-	50
Sedro-Woolley				
	structures:	parking shelter		3
		building		5
	roads:	service	-	
Newhalem				
	trees:	Doug. fir	25	8
		pine	15	2.5
		cedar	3	7
	roads:	public (light use)	-	14
Ross Dam				
	trees:	pine	5	5
		Doug. fir	40	8
		Doug. fir	20	20
	roads:	public (closed Nov.-Apr.)	-	20
Stehekin				
	structures:	residence		10

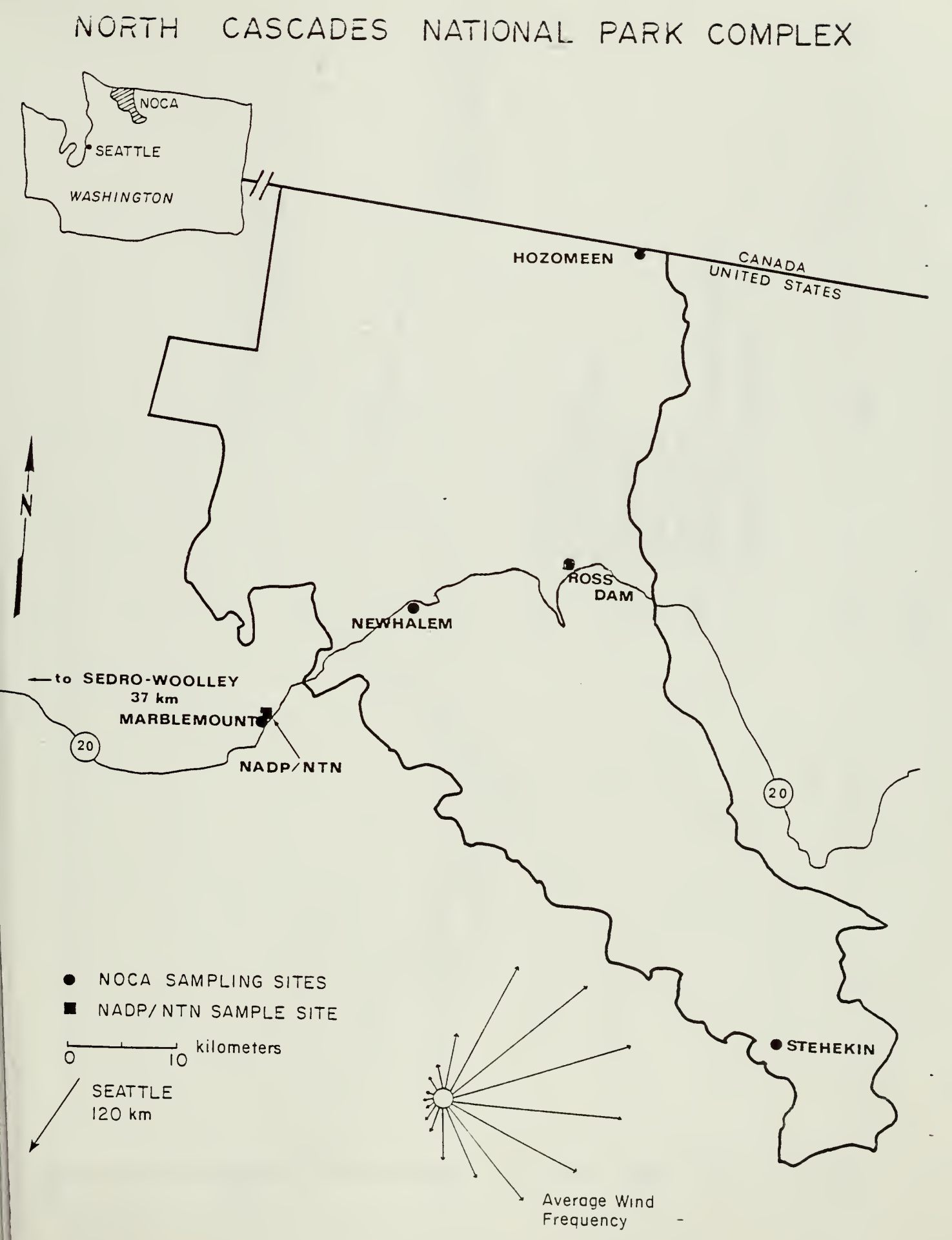

NORTH CASCADES NATIONAL PARK COMPLEX
NOCA
SEATTLE
WASHINGTON
HOZOMEEN
CANADA
UNITED STATES
N
ROSS
DAM
NEWHALEM
to SEDRO-WOOLLEY
37 km
MARBLEMOUNT
NADP/NTN
20
20
STEHEKIN
NOCA SAMPLING SITES
NADP/NTN SAMPLE SITE
0
10
kilometers
SEATTLE
120 km
Average Wind
Frequency

Figure 1

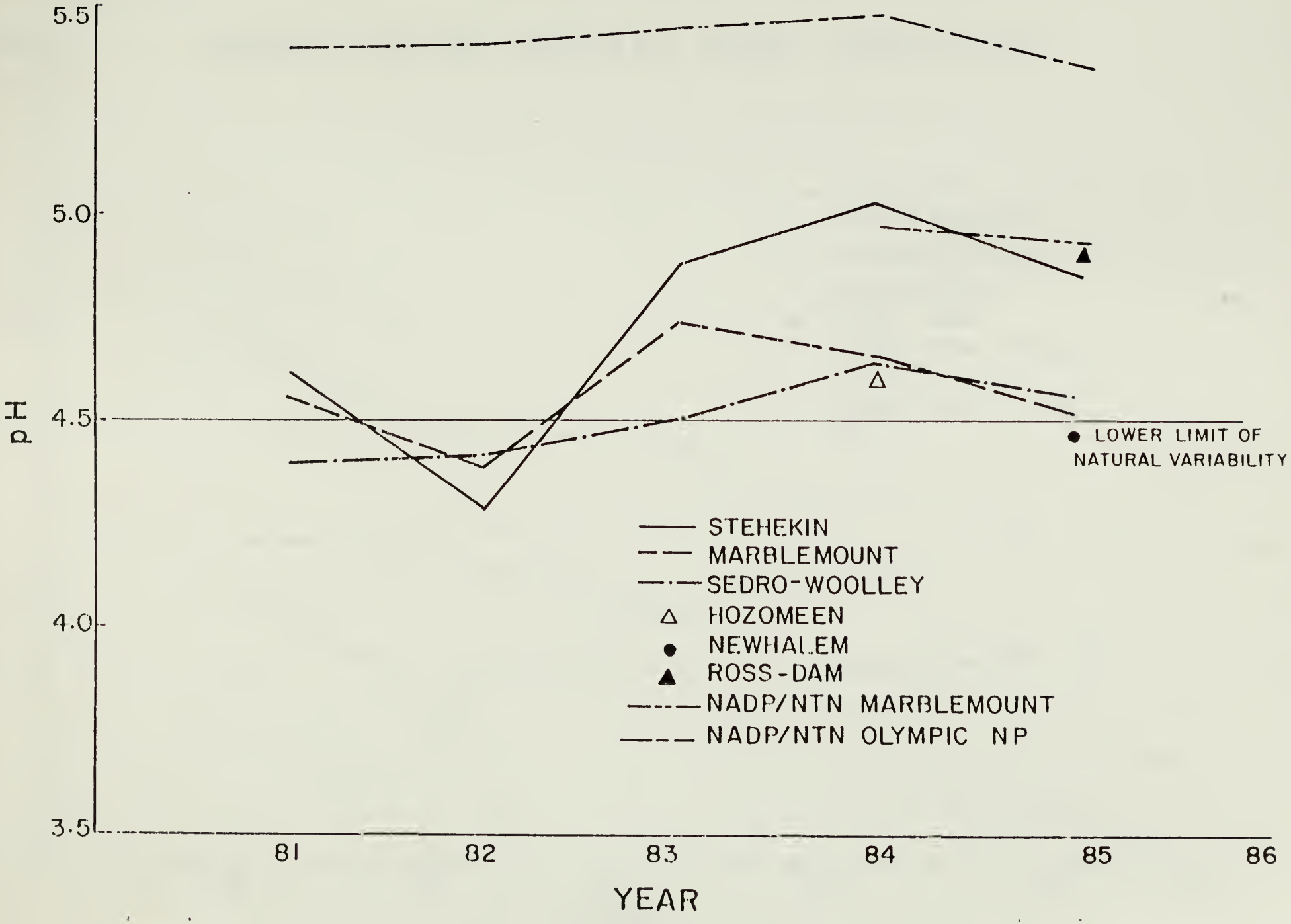
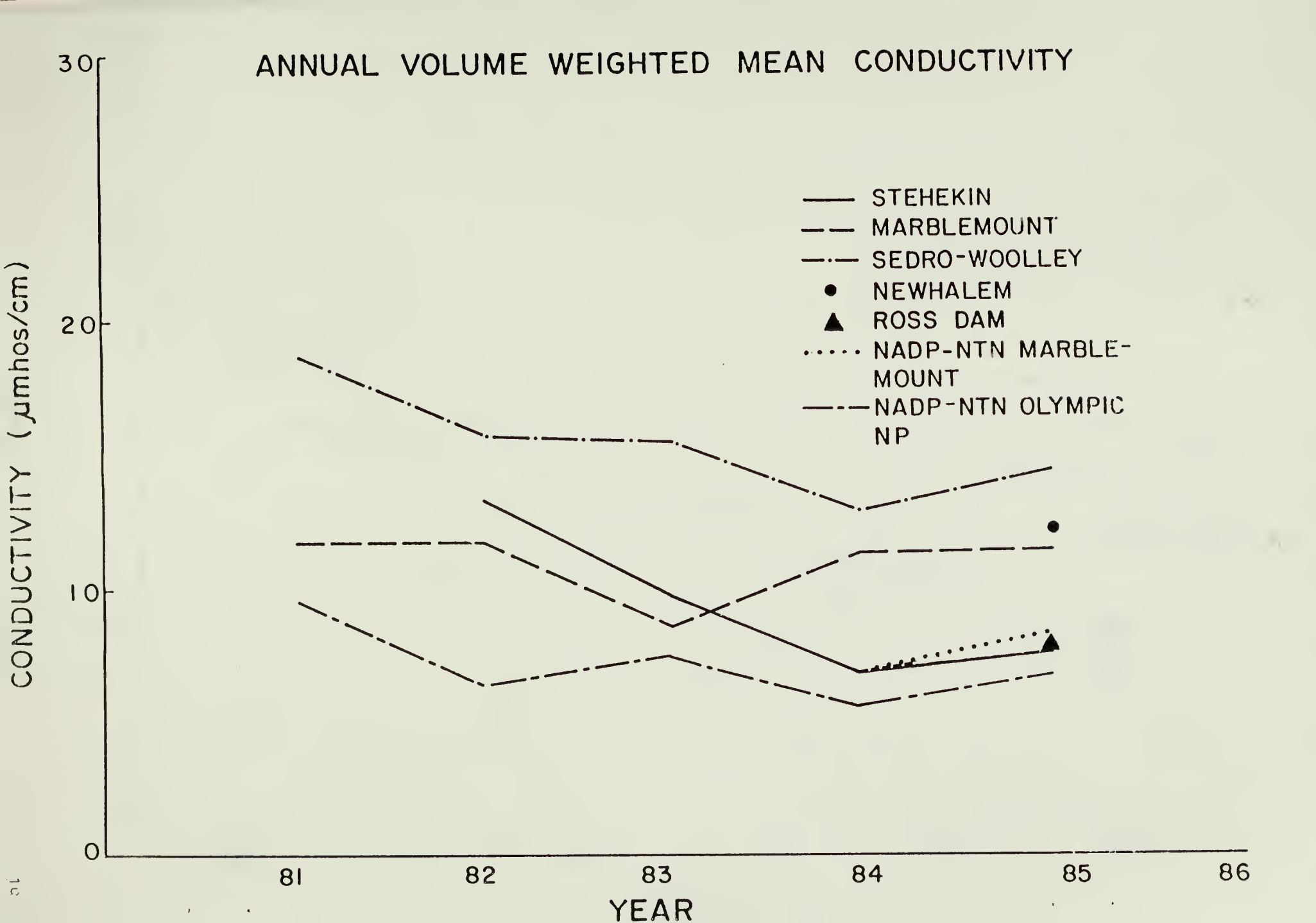
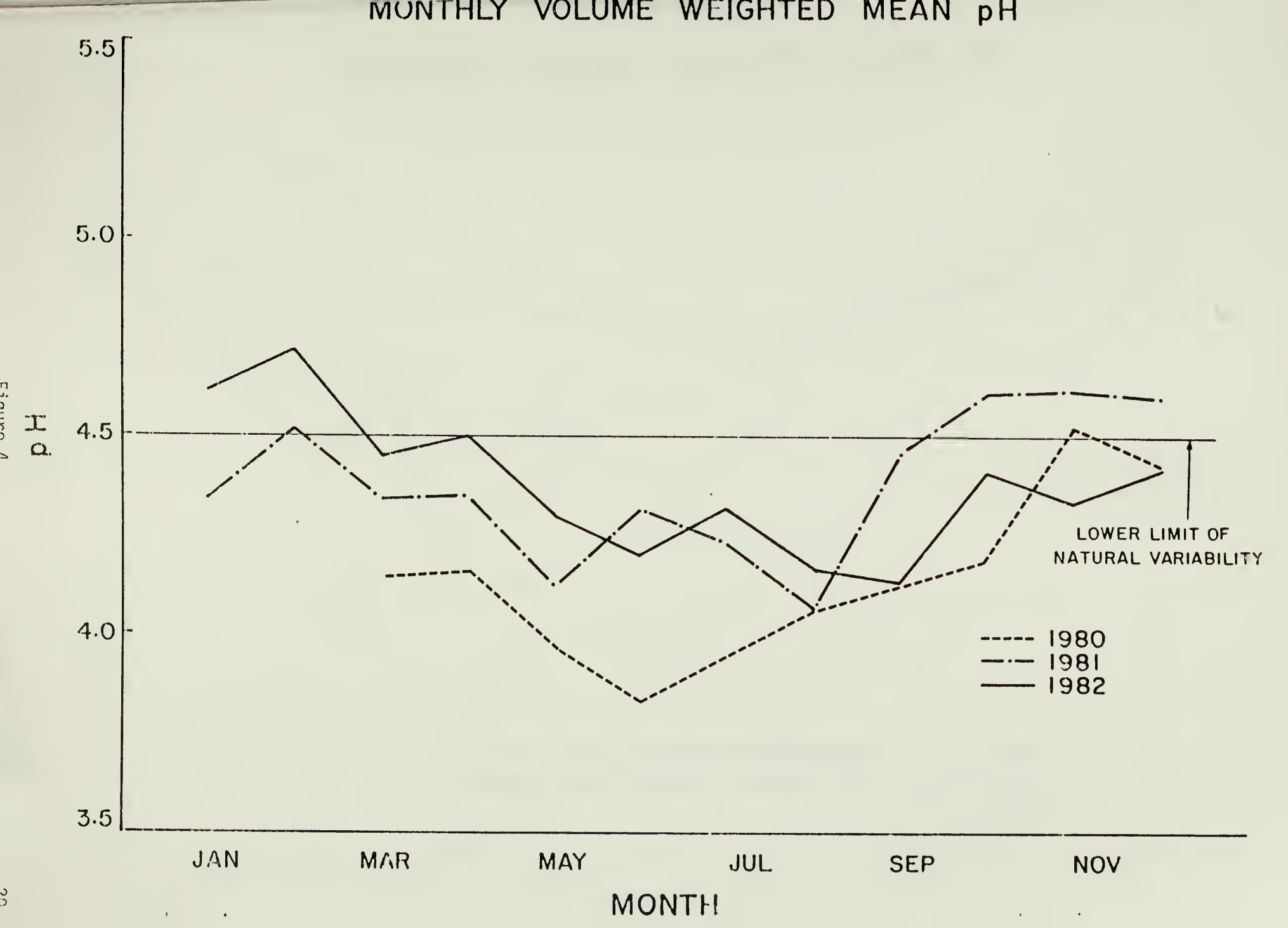

5.5
5.0
4.5
4.0
3.5
pH
81
82
83
84
85
86
YEAR
LOWER LIMIT OF
NATURAL VARIABILITY
STEHEKIN
MARBLEMOUNT
SEDRO-WOOLLEY
HOZOMEEN
NEWHALEM
ROSS-DAM
NADP/NTN MARBLEMOUNT
NADP/NTN OLYMPIC NP

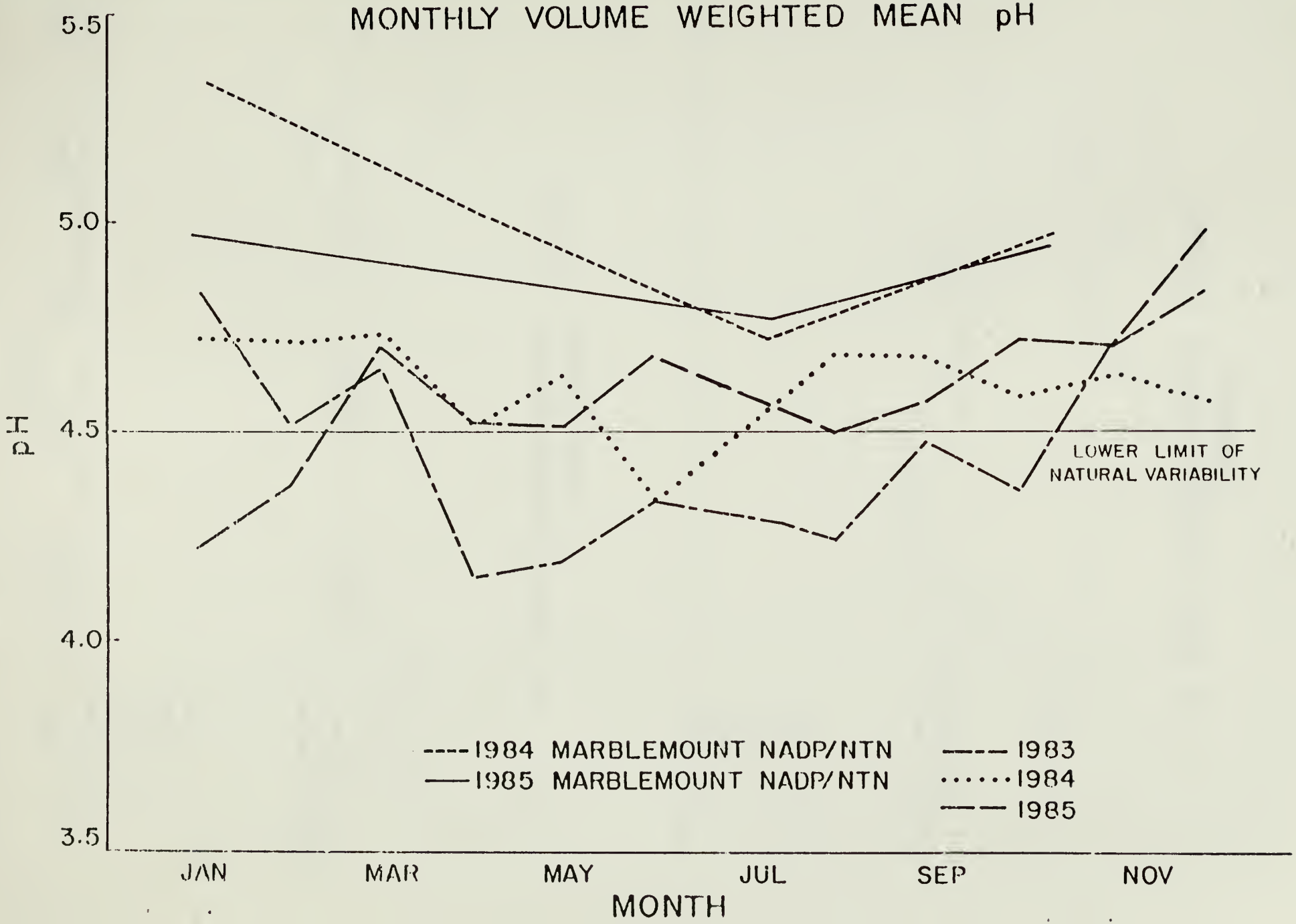
Figure 2

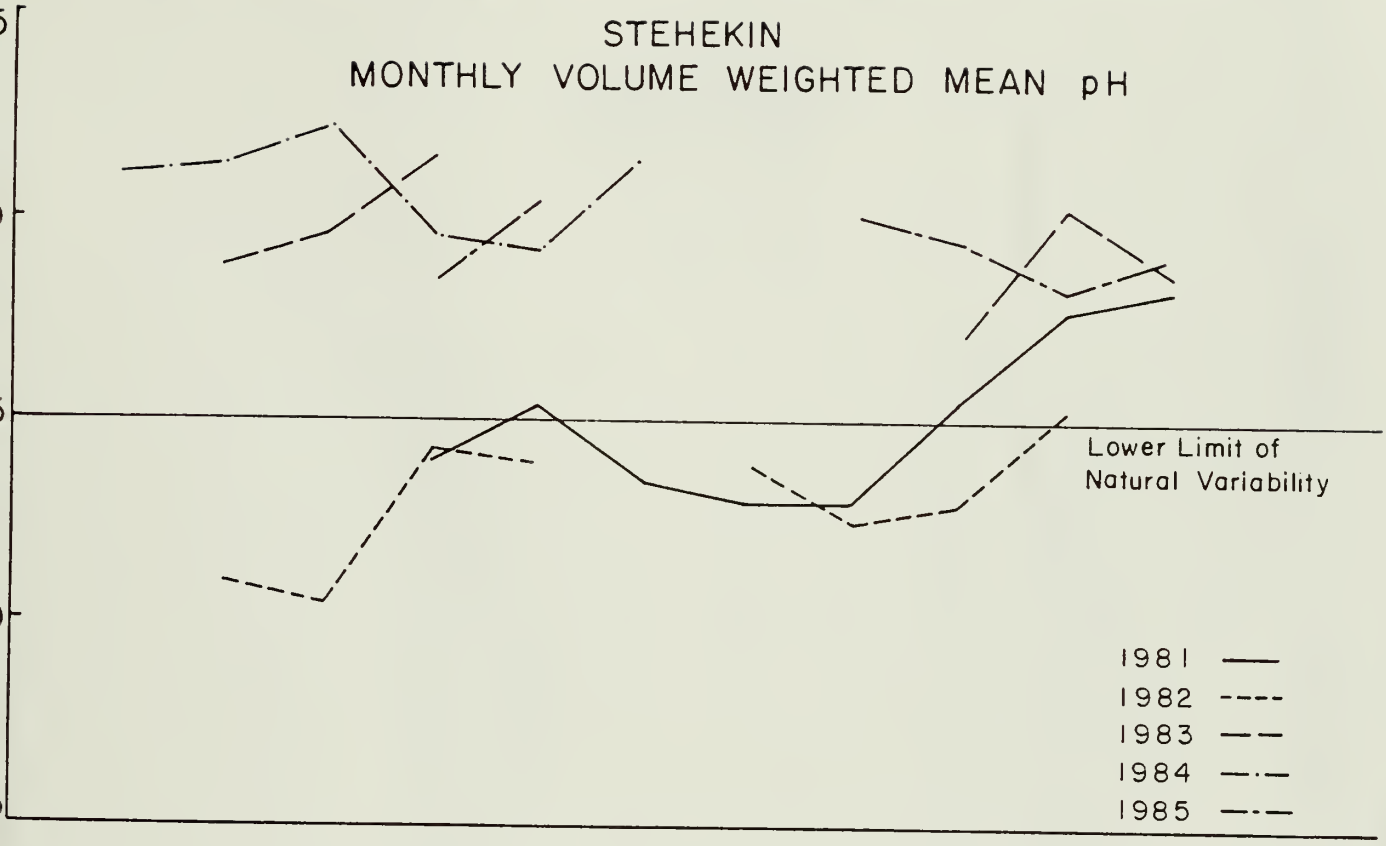

ANNUAL VOLUME WEIGHTED MEAN CONDUCTIVITY
30
20
10
0
CONDUCTIVITY (μmhos/cm)
81
82
83
84
85
86
YEAR
STEHEKIN
MARBLEMOUNT
SEDRO-WOOLLEY
NEWHALEM
ROSS DAM
NADP-NTN MARBLE-MOUNT
NADP-NTN OLYMPIC NP


MONTHLY VOLUME WEIGHTED MEAN pH
5.5
5.0
4.5
4.0
3.5
pH
LOWER LIMIT OF
NATURAL VARIABILITY
1980
1981
1982
JAN
MAR
MAY
JUL
SEP
NOV
MONTH

SEDRO-WOOLLEY

MONTHLY VOLUME WEIGHTED MEAN pH




STEHEKIN
MONTHLY VOLUME WEIGHTED MEAN pH
Lower Limit of
Natural Variability
1981
1982
1983
1984
1985

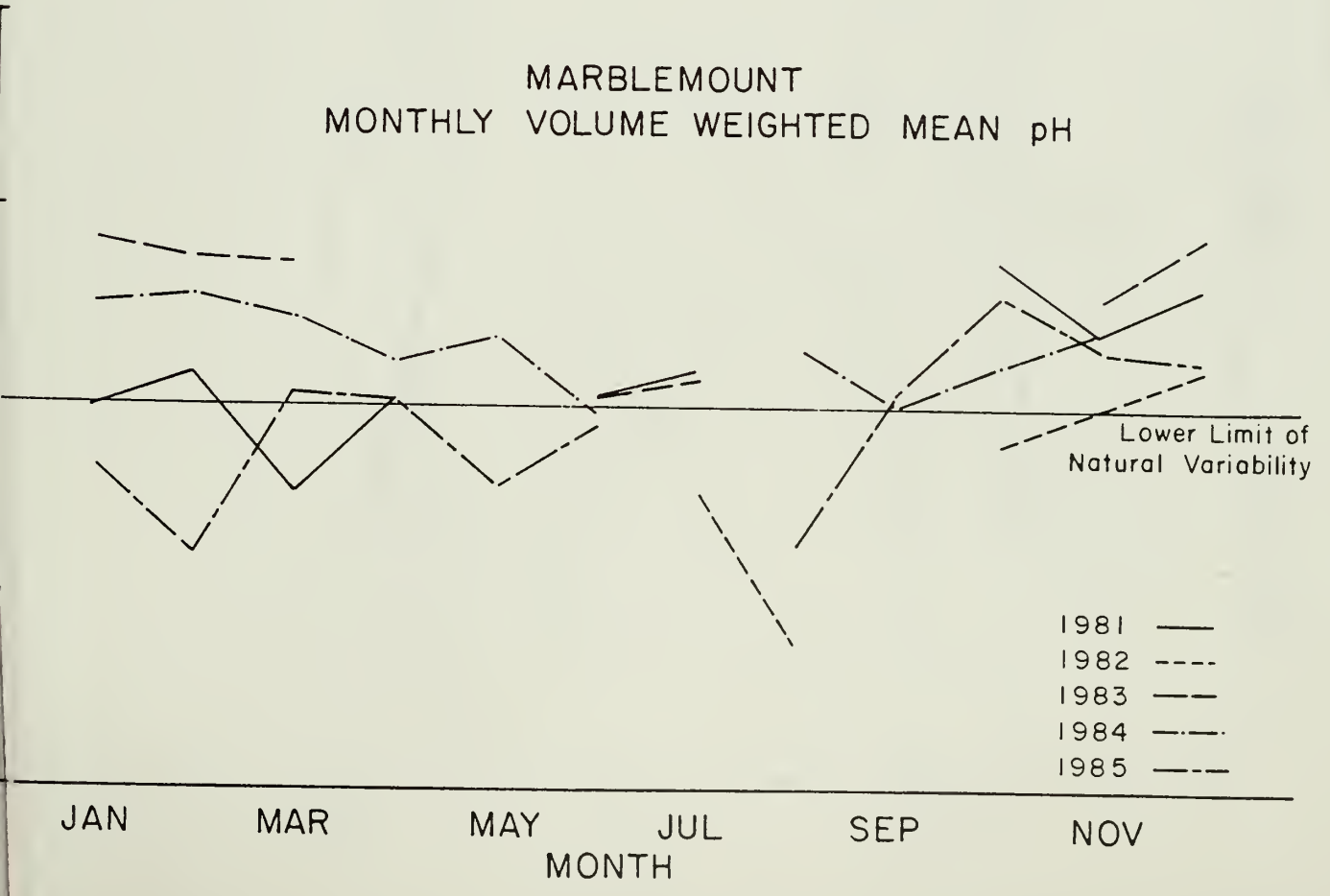
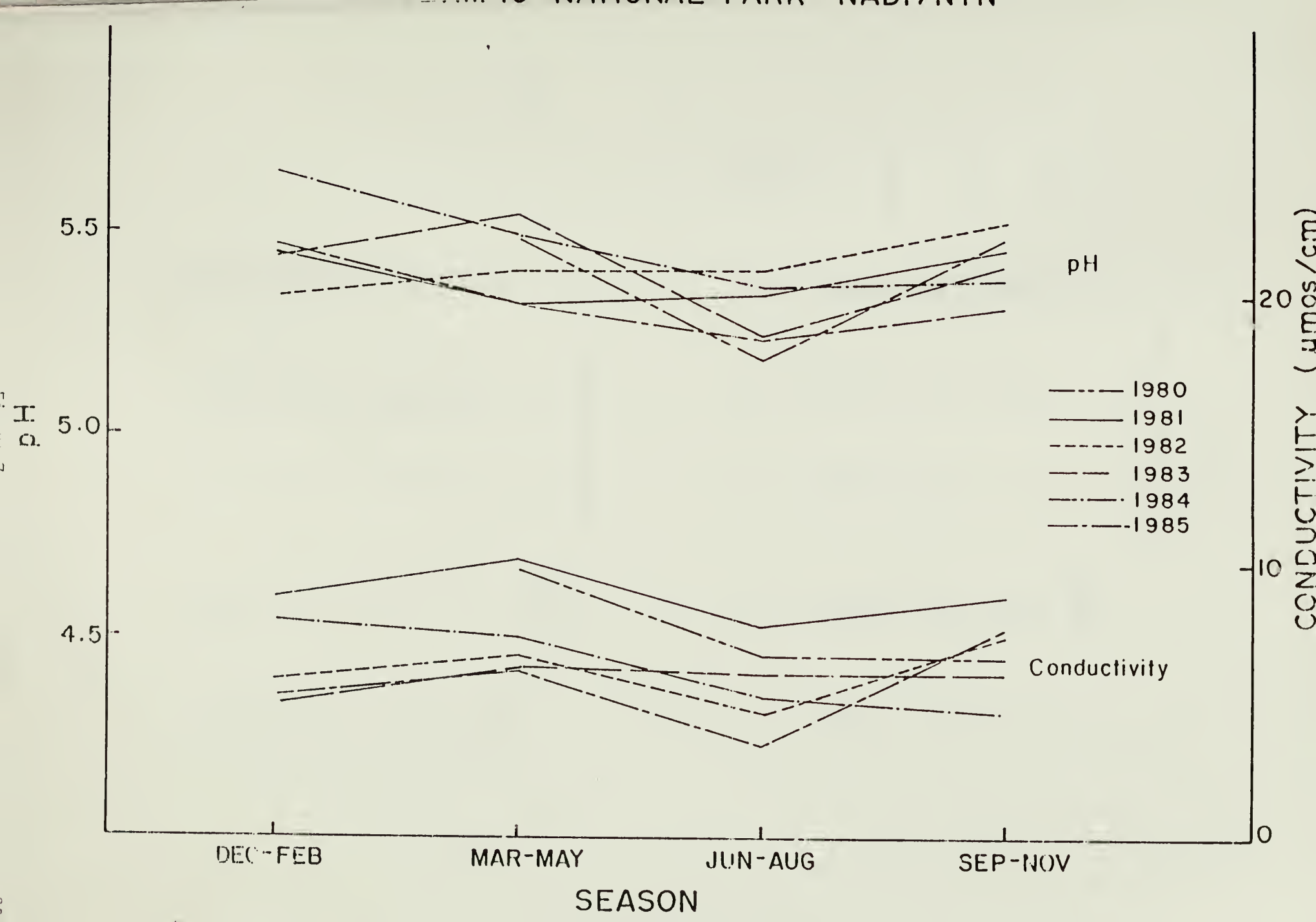

MARBLEMOUNT
MONTHLY VOLUME WEIGHTED MEAN pH
Lower Limit of
Natural Variability
1981
1982
1983
1984
1985
JAN
MAR
MAY
JUL
SEP
NOV
MONTH

Figure 6


5.5
5.0
4.5
pH
20
10
0
CONDUCTIVITY (µmos/cm)
1980
1981
1982
1983
1984
1985
Conductivity
DEC-FEB
MAR-MAY
JUN-AUG
SEP-NOV
SEASON

APPENDIX

North Cascades National Park Complex

Annual Volume Weighted Means

	Year	pH	n	Conductance (umho/cm)	n
Stehekin	1981	4.63	32	-	-
	1982	4.30	19	13.3	1
	1983	4.89	17	9.7	17
	1984	5.04	9	6.9	
	1985	4.87	15	7.6	15
Marblemount	1981	4.57	20	11.7	20
	1982	4.40	16	11.7	16
	1983	4.75	41	8.6	40
	1984	4.67	44	11.3	44
	1985	4.53	39	11.4	39
Sedro-Woolley	1980	4.15	57	16.6	54
	1981	4.41	91	18.7	86
	1982	4.43	76	15.7	72
	1983	4.52	110	15.5	104
	1984	4.65	109	12.9	109
	1985	4.57	79	14.4	79
Hozomeen	1984	4.61	18	-	-
Newhalem	1985	4.48	34	12.2	34
Ross Dam	1985	4.86	11	7.3	11

Monthly Volume Weighted Means

	Month	pH	n	Conductance (umho/cm)	n
Stehekin					
1981	Jan	-	-	-	-
	Feb	-	-	-	-
	Mar	-	-	-	-
	Apr	4.47	2	-	-
	May	4.53	4	-	-
	Jun	4.34	6	-	-
	Jul	4.30	1	-	-
	Aug	4.30	2	-	-
	Sep	4.55	4	-	
	Oct	4.80	5	-	-
	Nov	4.75	8	-	-
	Dec	-	-	-	-
1982	Jan	-	-	-	-
	Feb	4.10	1	-	-
	Mar	4.04	3	-	-
	Apr	4.42	3	-	-
	May	4.40	2	-	-
	Jun	-	-	-	-
	Jul	4.40	1	-	-
	Aug	4.25	3	-	-
	Sep	4.29	4	-	-
	Oct	4.53	2	13.3	1
	Nov	-	-	-	-
	Dec	-	-	-	-

1983	Jan	-	-	-	-
	Feb	4.88	4	7.2	4
	Mar	4.95	6	6.4	6
	Apr	5.15	1	13.2	1
	May	-	-	-	-
	Jun	-	-	-	-
	Jul	-	-	-	-
	Aug	-	-	-	-
	Sep	4.71	2	16.6	2
	Oct	5.03	1	17.6	1
	Nov	4.87	3	10.1	3
	Dec	-	-	-	-
1984	Jan	5.10	2	3.8	2
	Feb	5.13	1	7.4	1
	Mar	5.22	1	4.3	1
	Apr	4.95	2	8.7	2
	May	4.91	2	9.0	2
	Jun	5.16	1	27.3	1
	Jul	-	-	-	-
	Aug	-	-	-	-
	Sep	-	-	-	-
	Oct	-	-	-	-
	Nov	-	-	-	-
	Dec	-	-	-	-
1985	Jan	-	-	-	-
	Feb	-	-	-	-
	Mar	-	-	-	-
	Apr	4.83	3	8.2	3
	May	5.04	2	20.6	2
	Jun	-	-	-	-
	Jul	-	-	-	-
	Aug	5.01	1	9.6	1
	Sep	4.94	4	6.9	4
	Oct	4.82	3	7.2	3
	Nov	4.90	2	7.0	2
	Dec	-	-	-	-
Marblemount					
1981	Jan	4.48	2	10.9	2
	Feb	4.56	4	13.5	4
	Mar	4.27	1	17.1	
	Apr	4.52	6	12.1	6
	May	-	-	-	-
	Jun	4.52	1	11.6	1
	Jul	4.59	1	22.0	1
	Aug	-	-	-	-
	Sep	-	-	-	-
	Oct	4.86	2	5.6	2
	Nov	4.68	2	10.4	2
	Dec	4.80	1	8.2	1
1982	Jan	-	-	-	-
	Feb	-	-	-	-
	Mar	-	-	-	-
	Apr	-	-	-	-
	May	-	-	-	-
	Jun	-	-	-	-
	Jul	4.29	1	15.9	1
	Aug	4.07	2	23.0	2
	Sep	-	-	-	-
	Oct	4.39	5	13.1	5
	Nov	4.48	2	9.2	2
	Dec	4.58	6	7.0	6
1983	Jan	4.91	8	6.9	8
	Feb	4.86	5	7.4	5
	Mar	4.83	6	5.8	6
	Apr	-	-	-	-
	May	-	-	-	-
	Jun	4.41	3	15.2	3
	Jul	4.56	4	9.6	3
	Aug	-	-	-	-
	Sep	4.55	4	17.4	4
	Oct	4.54	1	11.0	1
	Nov	4.76	7	7.6	7
	Dec	4.92	3	7.7	3

1984	Jan	4.74	6	8.6	6
	Feb	4.74	9	8.6	9
	Mar	4.72	4	10.9	4
	Apr	4.62	4	16.8	4
	May	4.68	8	12.6	8
	Jun	4.47	6	17.9	6
	Jul	-	-	-	-
	Aug	4.65	1	10.2	1
	Sep	4.69	3	15.7	3
	Oct	4.59	3	15.4	3
	Nov	4.68	2	7.7	2
	Dec	-	-	-	-
1985	Jan	4.34	2	10.9	2
	Feb	4.18	3	19.1	3
	Mar	4.53	3	13.8	3
	Apr	4.53	3	11.4	3
	May	4.30	4	20.8	4
	Jun	4.43	5	12.9	5
	Jul	-	-	-	-
	Aug	4.21	3	26.8	3
	Sep	4.53	4	12.7	4
	Oct	4.77	6	8.25	6
	Nov	4.63	2	8.34	2
	Dec	4.61	4	14.1	4
Sedro Woolley					
1980	Jan	-	-	-	-
	Feb	-	-	-	-
	Mar	4.13	3	24.0	3
	Apr	4.14	7	15.3	7
	May	3.96	3	15.9	3
	Jun	3.82	6	26.9	6
	Jul	3.93	4	22.8	3
	Aug	4.05	3	23.4	3
	Sep	4.13	5	13.6	5
	Oct	4.18	5	20.3	3
	Nov	4.52	9	12.6	9
	Dec	4.93	11	11.6	11
1981	Jan	4.33	4	19.8	4
	Feb	4.51	10	14.1	9
	Mar	4.38	7	18.5	7
	Apr	4.34	12	17.6	11
	May	4.09	6	33.4	6
	Jun	4.31	12	21.5	12
	Jul	4.19	6	35.4	6
	Aug	4.41	2	27.3	2
	Sep	4.45	7	18.8	7
	Oct	4.60	10	13.6	9
	Nov	4.61	8	11.4	6
	Dec	4.59	7	18.5	7
1982	Jan	4.57	12	12.2	11
	Feb	4.71	10	9.7	10
	Mar	4.44	7	19.2	5
	Apr	4.49	5	18.9	5
	May	4.29	6	29.5	6
	Jun	4.19	2	25.7	2
	Jul	4.25	7	21.6	7
	Aug	4.16	4	19.7	4
	Sep	4.12	6	22.8	6
	Oct	4.40	5	17.1	5
	Nov	4.32	4	17.9	4
	Dec	4.40	8	13.2	7
1983	Jan	4.83	8	8.84	8
	Feb	4.51	11	18.4	11
	Mar	4.65	12	13.2	11
	Apr	4.16	9	30.4	8
	May	4.18	9	21.4	6
	Jun	4.33	12	17.5	11
	Jul	4.31	8	20.4	8
	Aug	4.25	4	25.2	3
	Sep	4.49	9	18.1	9
	Oct	4.34	8	24.6	8
	Nov	4.71	13	13.4	13
	Dec	4.83	7	7.72	7

1984	Jan	4.73	11	10.4	11
	Feb	4.72	11	11.7	11
	Mar	4.73	11	12.7	11
	Apr	4.54	13	21.5	13
	May	4.64	16	13.6	16
	Jun	4.47	9	15.8	9
	Jul	-	0	-	-
	Aug	4.62	4	14.1	4
	Sep	4.68	7	12.4	7
	Oct	4.59	10	15.9	10
	Nov	4.63	15	12.6	15
	Dec	4.59	6	13.5	6
1985	Jan	4.22	3	19.1	3
	Feb	4.36	21	16.5	21
	Mar	4.69	7	12.7	7
	Apr	4.52	7	17.9	7
	May	4.51	8	15.8	8
	Jun	4.69	5	8.99	5
	Jul	4.61	1	18.2	1
	Aug	4.51	5	16.8	5
	Sep	4.58	5	16.7	5
	Oct	4.73	9	13.2	9
	Nov	4.72	5	11.8	5
	Dec	4.99	3	9.3	3
Hozomeen					
1984	Jan	4.79	1	-	-
	Feb	4.56	1	-	-
	Mar	-	-	-	-
	Apr	4.59	1	-	-
	May	-	-	-	-
	Jun	4.69	3	-	-
	Jul	-	-	-	-
	Aug	4.43	4	-	-
	Sep	4.46	3	-	-
	Oct	4.53	2	-	-
	Nov	4.52	3	-	-
	Dec	-	-	-	-
Ross Dam					
1985	Jan	-	-	-	-
	Feb	-	-	-	-
	Mar	-	-	-	-
	Apr	-	-	-	-
	May	-	-	-	-
	Jun	-	-	-	-
	Jul	-	-	-	-
	Aug	-	-	-	-
	Sep	4.57	4	10.2	4
	Oct	4.92	5	7.1	5
	Nov	4.92	2	6.6	2
	Dec	-	-	-	-
Newhalem	Jan	-	-	-	-
	Feb	4.69	2	7.4	2
	Mar	4.60	5	10.5	5
	Apr	4.30	2	23.7	2
	May	4.53	4	14.3	4
	Jun	4.07	3	23.9	3
	Jul	4.09	1	29.4	1
	Aug	-	-	-	-
	Sep	-	-	-	-
	Oct	4.42	3	16.2	3
	Nov	4.55	1	8.7	1
	Dec	-	-	-	-
1985	Jan	4.19	1	10.3	1
	Feb	4.16	2	17.2	2
	Mar	4.56	3	15.3	3
	Apr	4.45	3	11.7	3
	May	4.26	3	28.0	3
	Jun	4.49	4	12.4	4
	Jul	3.89	1	50.7	1
	Aug	3.98	3	35.0	3
	Sep	4.48	4	13.2	4
	Oct	4.68	6	8.5	6
	Nov	4.57	2	10.7	2
	Dec	4.50	2	13.2	2